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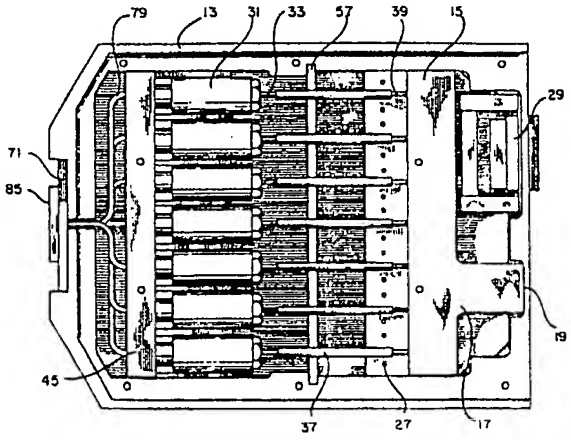
(54) Multipurpose fluid dispensing apparatus.

(57) The invention provides a dispensing apparatus for a fluid, notably a pressurised ink. A manifold is provided which is adapted to receive the medium to be dispensed. A plurality of solenoid valves, each having an input port and an output port, are connected to the manifold by connecting conduits. A series of rigid tubes connect the solenoid output ports with openings in a tube plate. A removable orifice plate overlays the tube plate and has a plurality of openings which are arranged in alignment with the tube plate openings. A valve cradle is provided for positioning the solenoid valves within the dispensing head. The valve cradle has a plurality of valve receptacles for receiving the respective output ports of the plurality of solenoid valves.

The invention also provides a valve for use in the dispensing apparatus of the invention which has an outer jacket with opposing ends and a plunger bore which communicates between the ends. An end cap is located on one of the jacket opposing ends and has an output port which communicates with the plunger bore. A plunger stop located on the jacket end opposite the end cap is at least partially received within the plunger bore and has an input port and internal passageway communicating the input port with the plunger bore. A plunger is slidably received within the plunger bore. An energizable electrical coil wound about the plunger bore allows the plunger to move between opened and closed positions in response to energization of the coil.



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TITLE: MULTIPURPOSE FLUID DISPENSING APPARATUS.

This invention relates to a high speed, multipurpose, fluid dispensing apparatus, notably, to a printing apparatus of the type used to dispense ink for printing graphic images onto a target substrate.

On-demand ink jet printing devices generally utilize some variation of a technique in which ink drops are issued only on demand rather than in a continuous stream. Typically, there is provided a plurality of nozzles through which ink can be intermittently and selectively ejected. It has been proposed to use electrically operated solenoid valves located between the ink source and the ink nozzles to dispense ink toward the target substrate. Such devices are relatively simple in construction and reliable in operation. However, they have been limited by the valve response time and, as a result, only relatively larger size characters, i.e., those having a height of from about 13mm to about 70mm, could be printed. Problems are also encountered in that it has been necessary to "back flush" the ink nozzles to clean the nozzles and correct plugging problems caused in part from the requirement to use small nozzle orifice diameters due to the slow acting valves. Also, the flexible conduits used to connect the valve output ports to the fluid nozzles tended to swell when filled with pressurized ink, thereby acting as an accumulator and

resulting in residual ejection of ink from the nozzle after the valve had closed. Furthermore, shorting of the electrical components occurred when fluid leakage contacted the electrical circuitry of the device.

We have now devised a dispensing apparatus which reduces these problems. Accordingly, the present invention provides a dispensing apparatus for dispensing a medium characterised in that it comprises:

a manifold adapted to receive a medium;

a plurality of solenoid valves, each of said valves having an input port and an output port;

conduit means connecting said manifold with each of said solenoid input ports;

a tube plate having a plurality of openings therein;

tube means for connecting each of said tube plate openings with a selected one of said solenoid output ports; and

a removable orifice plate overlaying said tube plate, said orifice plate having a plurality of openings therein, said openings being arranged to be aligned with said tube plate openings.

Preferably, the openings in the tube plate are of greater relative diameter than the openings in the orifice plate.

Preferably, a plurality of rigid tubes are provided,

each of the rigid tubes connecting a selected one of the solenoid output ports with a selected one of the tube plate openings. Preferably, the tubes are made of stainless steel.

A valve cradle is preferably provided for positioning the solenoid valves within the dispensing apparatus. Preferably, the valve cradle has a plurality of valve receptacles for receiving the respective output ports of the plurality of solenoid valves. The tube means connect each of the tube plate openings with a selected one of the valve receptacles in the valve cradle. The valve cradle preferably includes a cradle wall containing the valve receptacles, the cradle wall having an inside face and an outside face and the receptacles comprising a series of stepped bores between the inside face and outside faces. The valve receptacle bores decrease in internal diameter from the inside face to the outside face and resilient seal means surround the valve output ports within the valve receptacles.

A base portion depends from the valve cradle wall and has a plurality of arcuate troughs adapted to receive the solenoid valves. The arcuate troughs are preferably arranged in side-by-side fashion with the longitudinal axes of the troughs being parallel to form a scalloped cross-sectional pattern. The tube means are rigidly

affixed to the receptacle bores on the cradle wall outside face. Biasing means are provided for urging the solenoid valves in the direction of the cradle wall receptacles.

The valve for use in the liquid dispensing apparatus has an elongated outer jacket with opposing ends. A plunger bore is centrally located within the jacket and communicates between the opposing ends. An end cap located on one of the jacket opposing ends has an output port therein which communicates with the plunger bore. A plunger stop located on the jacket end opposite the end cap is at least partially received within the plunger bore. The plunger stop has an input port and an internal passageway communicating the input port with the plunger bore. A plunger is slidably received within the plunger bore between the plunger stop and the end cap.

An energizable electrical coil is wound about the plunger bore within the jacket. The plunger is slidable within the plunger bore between a closed position and an open position for allowing fluid flow through the input port, the internal passageway, plunger bore, and output port in response to energization of the coil. Preferably, the input port, plunger bore, and output port are longitudinally aligned to provide a straight through flow of ink through the valve. The plunger stop is

threadedly received within the valve end opposite the end cap and is adjustable within the plunger bore to provide a gap between the stop and the plunger, the size of the gap determining the distance of travel of the plunger between the open and the closed positions. Biasing means are provided for normally urging the plunger toward the end cap closed position.

Preferably, the plunger stop has a generally cylindrical portion adapted to be received within the plunger bore and an internal passageway running parallel to the longitudinal axis of the cylindrical portion along a part of the length thereof and having a terminating path portion arranged normal to the longitudinal axis of the cylindrical portion. The terminating path portion ends in a fluid aperture which communicates with the plunger bore. The plunger stop cylindrical portion has a stop end opposite the threaded end, the stop end being of lesser relative external diameter than the cylindrical portion. The plunger has a generally cylindrical body with a plunger face for contacting the interior of the end cap to seal the outlet port and an opposite plunger end of lesser relative diameter than the cylindrical body, whereby a spring can be fitted about the stop end and about the plunger end within the plunger bore, the spring serving to urge the plunger face toward the end

cap to seal the output port.

A particularly preferred form of the dispensing apparatus of the invention will now be described by way of example with reference to the accompanying drawings in which:

Fig. 1 is a top perspective view of the dispensing apparatus of the invention with the top cover of the housing removed.

Fig. 2 is an exploded perspective view of the dispensing apparatus of Fig. 1.

Fig. 3 is an isolated view of the valve, valve cradle, and tube plate of the dispensing apparatus of Fig. 1 with parts broken away.

Fig. 4 is an isolated view of the tube plate of the dispensing apparatus with a jeweled orifice plate.

Fig. 5 is an isolated, cross-sectional view of an orifice jewel.

Fig. 6 is an isolated view of the tube plate of the dispensing apparatus with a drilled orifice plate.

Fig. 7 is a side cross-sectional view of the valve of the dispensing apparatus.

Turning to Fig. 1, there is shown a dispensing apparatus of the invention designated generally as 11. The dispensing apparatus 11 has a housing 13 into which is fitted a manifold 15 which is adapted to receive a

pressurized liquid. The housing 13 is a generally rectangular box, as shown in Fig. 2, and has a front interior portion 12, a bottom wall 14, and a protrusion 16 in the interior sidewalls 18 which separates the front interior portion 12 from a rear interior portion 20. The rear sidewall 24 of housing 13 includes an elongated slot 22 and the front sidewall 26 has a recess 69 which will be described later in greater detail. A top cover (not shown) can be provided for the housing.

As best seen in Fig. 2, the liquid manifold 15 is a generally rectangular member having a leg portion 17 with an end opening 19 which is adapted to receive a tube union 21 whereby the manifold can be connected to a source of pressurized liquid. The tube union 21 also provides a convenient point for insertion of a final filter 23 for the liquid being dispensed.

The dispensing apparatus of the invention is particularly well suited for dispensing printing inks of the type used to print on a target substrate, including both porous and non-porous target substrates. The liquid medium suitable for use with the present dispensing head can thus include water based inks and solvent inks. Suitable solvents include chlorinated hydrocarbons, ketones, alcohols, and oil bases, e.g. xylene. It should be understood, however, that the apparatus of the

invention is capable of dispensing other fluid mediums such as adhesives and the like, or gases.

The manifold 15, as seen in Fig. 2, is mounted on a printed circuit board 25 having a series of terminal posts 27 which run to a connector plug 29. The circuit board 25 is coated with a surface coating which is resistant to solvent attack. Preferably, the coating is a conformal coating which forms a thin seal around the board.

A plurality of solenoid valves 31 are provided, each of which has an input port 33 and an output port 35. Conduit means, in this case Teflon tubing 37, connects the manifold 15 with each of the solenoid input ports 33 by means of manifold outlets 39.

A valve cradle 41 is provided for positioning the solenoid valves 31 within the dispensing apparatus 11. The valve cradle 41 has a plurality of valve receptacles 43 (see Fig. 3). The valve receptacles 43 are adapted to receive the respective output ports 35 of a solenoid valve 31. The valve cradle 41 includes a cradle wall 45 which contains the valve receptacles 43. The wall has an inside face 47 and an outside face 49 and the receptacles 43 comprise a series of stepped bores between the inside face 47 and the outside face 49. As seen in Fig. 3, the valve receptacle bores decrease in internal diameter from

the inside face 47 to the outside face 49. Resilient seal means, in this case O-rings 51, surround the valve output ports 35 within the valve receptacle stepped bore.

The valve cradle 41 also includes a base portion 53 depending from the cradle wall 45, generally normal thereto, which has a plurality of arcuate troughs 55 adapted to receive the solenoid valves 31.

A spring plate 57 (see Fig. 2) is adapted to be received within a groove 59 in the housing 13 and includes a plurality of circular openings 61 with top slots 63. The circular openings 61 are adapted to receive an end of a biasing means, such as springs 65, which surround the input ports 33 of the solenoid valves 31, thereby urging valves 31 in the direction of the valve receptacles 43 in the valve cradle 41. The slots 63 and springs 65 provide ease of insertion and removal of the valves 31 from the valve cradle 41 and dispensing apparatus 11.

The arcuate troughs 55 in the cradle base portion 53 are arranged in side-by-side fashion with the longitudinal axes (67 in Fig. 3) being parallel to form a scalloped cross-sectional pattern. The valve cradle 45, as shown in Fig. 2, is received within the front portion 12 of the housing 13 and is supported by the bottom wall 14 of the housing 13. The protrusion 16 in the housing

interior sidewalls 18 fixes the valve cradle in position and prevents sliding movement of the valve cradle. The manifold 15 and circuit board assembly 25 are received within the rear portion 20 of the housing 13. The elongated slot 22 in the rear sidewall 24 of the housing 13 receives the connector plug 29 of the circuit board 25. Each solenoid valve 31, as will be more fully described, has a pair of electrical wires which run from the valve to the appropriate terminal post 27 on the printed circuit board 25.

As seen in Fig. 2, the housing 13 includes a recess 69 in the front sidewall 26 which is adapted to receive a tube plate 71 which can be fixed in position as by screw holes 73. The housing recess 69 includes a vertical slot 75 in the mid region thereof. The tube plate 71 has a plurality of openings 77 therein for receiving tube means, in this case rigid tubes 79, which connect each of the tube plate openings 77 with a selected one of the valve cradle receptacles 43. The rigid tubes 79 are preferably 17 or 18 gauge stainless steel and are connected by gluing the ends thereof with epoxy into the respective receptacle openings 81 and tube plate interior openings 83 (see Fig. 3). A removable orifice plate 85 (Fig. 2) overlays the tube plate 71 within the housing recess 69 and can be secured thereto by means of

screw holes 87 provided for screws which are received within the threaded bores 89 in the tube plate 71. The removable orifice plate 85 includes a plurality of openings 91, the openings 91 being arranged in alignment with the tube plate openings 77. The openings in the tube plate 71 are of greater relative diameter than the ultimate openings in the orifice plate 85, as will be described.

Fig. 4 shows a tube plate, orifice plate arrangement for the present invention. As shown in Fig. 4, the orifice plate 85 has openings 91 which are adapted to receive orifice jewels 93. The orifice jewels 93 are jewels such as the sapphire jewels used in acetylene torches and the like. Each jewel 93 (see Fig. 5) has a generally circular body 95 having an orifice 97 of relatively smaller diameter on one face 99 and an opening 101 of relatively greater diameter on the opposite face 103. The diameter of orifice 97 is in the range 0.025 mm to 0.508 mm, and preferably for ink jet printing is in the range of 0.145 mm to 0.254 mm. The length "l" of the orifice throat 105 is in the range of 0.145 to 0.254 mm. The internal diameter of the openings 91 in the orifice plates 85 are sufficient to receive the external diameter of the jewel bodies 95. The openings 91 are of sufficient depth to allow the jewels 93 to fit flush with

the top surface 107 of the orifice plate 85 when the jewels are in place. The jewels are placed in the openings 91 with the opening 101 being first to enter the opening 91. A Teflon gasket 109, as shown in Fig. 4, is received within a groove 111 in the rear of orifice plate 85 and is retained between the orifice plate 85 and tube plate 71 with the openings 113 in the gasket 109 in alignment with the tube plate openings 77 and the orifice plate openings 91.

Another embodiment of the tube plate and orifice plate are illustrated in Fig. 6. The tube plate 115 has a series of stepped bores 117 which decrease in internal diameter from the top surface 119 to the rear surface 121 of the tube plate 115. The bores 117 in tube plate 115 are adapted to receive a sealing means such as O-rings 123.

A removable, orifice plate 125 overlays the tube plate 115 and has a plurality of openings 127 which are adapted to be aligned with the openings in the O-rings 123 and bores 117 in the tube plate 115. The orifice plate 125 can be secured to the tube plate 115 as by screw holes 129. In this embodiment, the diameter of the openings 127 in the orifice plate 125 corresponds to the size of the orifice openings 97 of the jewels 93 previously discussed. The thickness of the orifice plate

125 adjacent the openings 127 corresponds to the length of the jewel throat 105 and is in the range from 0.0254 to 0.0254 mm. A retaining plate 131 is received over the orifice plate 125 and retained in position by means of screw holes 78. The retaining plate 76 includes a longitudinal slot 135 which is aligned with the openings 127 in orifice plate 125.

The valve 31 for use in the liquid dispensing head 11 of the invention is shown in greater detail in Fig. 7. The valve 31 includes an elongated outer jacket 137 having opposing ends 139, 141. A plunger bore 143 is centrally located within the outer jacket 137 and communicates between the opposing ends 139, 141. An end cap 145 is located on one of the jacket opposing ends 139 and has an output port 35 which communicates with the plunger bore 143 by means of an opening 147 in a plunger seat 149.

A plunger 151 stop is located on the jacket end 141 opposite end cap 145 and is at least partially received within the plunger bore 143. The plunger stop 151 has an input port 33 and an internal passageway 153 which communicates the input port 33 with the plunger bore 143. The plunger stop 151 is preferably received within an inlet body 155 which has an internally threaded surface 157 adapted to matingly engage an externally

threaded surface 159 of the plunger stop 151. Alternatively, the stop can be preadjusted and permanently fixed in position within the plunger bore. The external diameter of the plunger stop decreases from the threaded surface 159 and is received within a mating bore 161 of the inlet body 155 where it sealingly engages the inlet body 155 by means of an O-ring 163.

A plunger 165 is slidably received within the plunger bore 143 between the plunger stop 151 and the end cap 145. An energizable electrical coil 167 is wound about the plunger bore 143 and is separated therefrom by means of a tube 169 within the jacket 137. The plunger 165 is slidable within the plunger bore 143 between a closed position, as shown in Fig. 6, and an open position for allowing fluid flow through the input port 33, the internal passageway 153, the plunger bore 143, and the output port 35 in response to energization of the electrical coil 167. A pair of outlet leads 171, 173 run from each of the valves 31 to a pair of terminal posts (27 in Fig. 2) on the printed circuit board 25. The valve jacket 137 is epoxy sealed to prevent valve deterioration. The jacket encapsulates the electrical coil and serves as the magnetic return path of the valve.

An electrical control means, such as a microcomputer (not shown) can be connected by means of the connector

plug 29 and the printed circuit board 25 to the valve leads 171, 173. The valves 31 can then be selectively and intermittently actuated by the electrical control means to allow fluid flow from the manifold 17 through the valve output ports 35 to the orifice plate 85 and onto a printing substrate (not shown). The selective actuation of the valves 31 by the electrical control means allows the fluid to be dispensed from the orifice plate.

As shown in Fig. 7, the input port 33, plunger bore 133, and output port 35 are longitudinally aligned to provide a straight through flow of fluid through the valve 31 to eliminate the possibility of air being trapped in the valve. The plunger stop 151 is adjustable by means of the threaded surfaces 157, 159 within the plunger bore 143 to provide a gap 175 between the stop 151 and the plunger 165. The size of the gap 175 determines the distance of travel of the plunger 165 between of the open and closed positions.

The plunger stop 151 has a generally cylindrical portion 177 which is adapted to be received within the plunger bore 143. The plunger stop internal passageway 153 runs parallel to the longitudinal axis 179 of the cylindrical portion 177 along a part of the length thereof, as shown in Fig. 7. The internal passageway 153

also has a terminating path portion 181 arranged normal to the longitudinal axis 179 of the cylindrical portion 177, the terminating path portion 181 ending in a fluid aperture 183. Fluid aperture 183 communicates with the plunger bore 143 by means of the space 185 between the cylindrical portion 177 of the plunger stop 151 and the internal diameter of the tube 169. The difference in diameter of the stop portion 177 and tube 169 is preferably on the order of 0.127 mm.

The plunger stop cylindrical portion 177 has a stop end 187 opposite the threaded end 159, the stop end 187 being of lesser relative external diameter than the cylindrical portion 177. Preferably, the plunger 165 has a generally cylindrical body 189 although other plunger designs are possible such as plungers with flat sides or fluted sides. The plunger also has a face 191 which is preferably an elastomeric material which is compatible with the medium being dispensed. The plunger face 191 contacts the plunger seat 149 at the point at which the seat slanting sidewalls 193 merge to form the opening 147. Fluid communication between the plunger bore 143 and the outlet port 35 only exist when the plunger face 191 is out of contact with the plunger seat 149.

The plunger 165 also has a region of lesser relative diameter 188. The portions of lesser relative diameter

of the stop end and plunger end 187, 188 allow a biasing means such as a spring 195 to be fitted about the stop end 187 and plunger end within the plunger bore 143. The spring 195 serves to urge the plunger face toward the end cap 145 to seal the outlet port 35.

The internal diameter of the plunger bore 143 is preferably in the range of about 3.289 to 3.390 mm with the most preferred diameter being about 3.378 mm. The external diameter of the plunger cylindrical portion 177 is preferably in the range of about 3.162 to 3.263 mm with the most preferred diameter being about 3.2512 mm. The preferred valve gap 175 is in the range of about 0.0762 to 0.2159 mm.

With the valve dimensions discussed, the valve can operate between the open and closed positions in the range of 1200 cycles per second with liquid mediums having viscosities in the range of 1.0 to 10 centipoise, with the preferred liquid viscosities for ink jet printing being in the range of about 1.0 to 4.2 centipoise.

The operation of the dispensing apparatus will now be described, with reference to Figs. 1 and 2. The medium to be dispensed, such as ink, is supplied to the manifold 17 through the opening 19 from a pressurized source. The supply pressure is preferably in the range of 1.5 to 90

psi, with the optimum pressure being about 6.0 psi for ink jet printing. The medium flows out the outlets 39 of the manifold 17 through the conduits 37 to the inlet ports 33 of the respective solenoid valves 31. The solenoid valves 31 are selectively actuated by the electrical control means, as has been described, with the electrical signals passing through the connector plug 29, terminal post 27 and electrical leads 171, 173 to the valves 31. As each valve is opened, liquid flows from the outlet port 35 through the valve receptacle opening 43 and through the rigid tubes 79 to the openings 77 in the tube plate 71. The liquid is then dispensed through the orifice openings in the orifice plate 85.

An invention has been provided with significant advantages. The dispensing apparatus of the invention has a removable nozzle plate which reduces the necessity of back flushing the system to service the orifices. The rigid tubes connecting the valve cradle with the tube plate reduce resilience problems caused by the use of flexible tubing which hitherto hes caused the tubing to act as an accumulator, resulting in the residual ejection of fluid from the orifices after the valves were closed which reduces the maximum operating speed of the system. The novel valve cradle design provides a means for joining the rigid tubes to the valve outlet ports while,

at the same time, providing ease of insertion and removal of the individual solenoid valves. The coated printed circuit board reduces electrical shorts in case of liquid contact with the board. A printed circuit board has been found to more effectively isolate the electrical signals being sent to the valves from the electrical control means to prevent shorts. The epoxy sealed valves are likewise insulated from liquid contamination. The minimum profile of the dispensing apparatus allows a series of dispensing apparatus to be stacked one upon the other to allow multiple line printing with a minimum space between lines. Using the dispensing apparatus of the invention, the space between lines can be kept to 0.254 mm or less. The faster response time of the solenoid valves of the invention allows smaller, more precisely defined characters to be printed.

While the invention has been shown in only two of its forms, it is not thus limited but is susceptible to various changes and modifications without departing from the spirit thereof.

CLAIMS:

1). A dispensing apparatus for dispensing a medium characterised in that it comprises:

a manifold adapted to receive a medium;

a plurality of solenoid valves, each of said valves having an input port and an output port;

conduit means connecting said manifold with each of said solenoid input ports;

a tube plate having a plurality of openings therein;

tube means for connecting each of said tube plate openings with a selected one of said solenoid output ports; and

a removable orifice plate overlaying said tube plate, said orifice plate having a plurality of openings therein, said openings being arranged to be aligned with said tube plate openings.

2). The dispensing apparatus of claim 1, characterised in that the openings in said tube plate are of greater diameter than the openings in said orifice plate.

3). The dispensing apparatus of claim 2, characterised in that each of the orifice plate openings is adapted to receive an orifice jewel to act as a fluid nozzle.

4). A dispensing apparatus as claimed in any one of the preceding claims characterised in that there is a plurality of rigid tubes, each of said tubes connecting a selected one of said solenoid output ports with a

selected one of said tube plate openings.

5). A dispensing apparatus as claimed in any one of the preceding claims characterised in that there is provided a valve cradle for positioning said solenoid valves within said dispensing head, said valve cradle having a plurality of valve receptacles for receiving the respective output ports of said plurality of solenoid valves.

6). A dispensing apparatus as claimed in claim 5 characterised in that the valve cradle includes a cradle wall containing said valve receptacles, said wall having an inside face and an outside face and said receptacles comprising a series of stepped bores between said inside face and said outside face.

7). A dispensing apparatus as claimed in claim 6 characterised in that the valve receptacle bores decrease in internal diameter from said inside face to said outside face.

8). A valve for use in a fluid dispensing apparatus characterised in that it comprises:

an elongated outer jacket having opposing ends;

a plunger bore substantially centrally located within said jacket, communicating said opposing ends;

an end cap located on one of said jacket opposing ends, said end cap having an output port therein

which communicates with said plunger bore;

a plunger stop located on said jacket end opposite said end cap, said plunger stop being at least partially received within said plunger bore, and said plunger stop having an input port and an internal passageway communicating said input port with said plunger bore;

a plunger slidably received within said plunger bore between said plunger stop and said end cap; and

an energizable electrical coil wound about said plunger bore within said jacket, said plunger being slidable within said plunger bore between a closed position and an open position for allowing fluid flow through said input port, internal passageway, plunger bore, and output port, in response to energization of said coil.

9). A valve as claimed in claim 8 characterised in that the plunger stop has a generally cylindrical portion adapted to be received within said plunger bore, said plunger stop internal passageway running parallel to the longitudinal axis of said cylindrical portion along a part of the length thereof and having a terminating path portion arranged normal to the longitudinal axis of said cylindrical portion, said terminating path portion ending in a fluid aperture which communicates with said plunger

bore.

10). A valve of claim 20, as claimed in either of claims 8 or 9 characterised in that the plunger has a generally cylindrical body with a plunger face for contacting the interior of said end cap to seal said outlet port and an opposite plunger end of lesser relative diameter than said cylindrical body, whereby a spring can be fitted between said stop and said plunger end within said plunger bore, said spring serving to urge said plunger face toward said end cap to seal said outlet port.

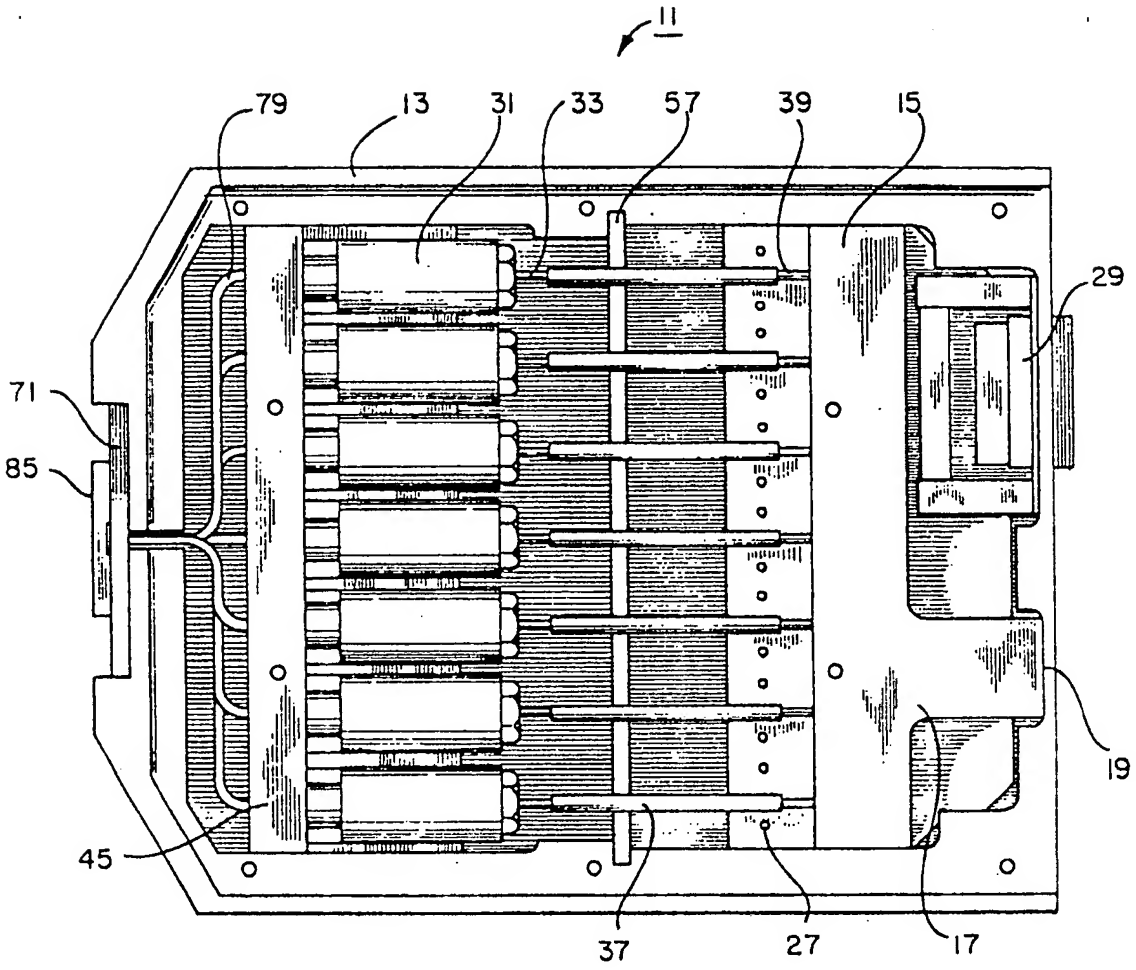

FIG. 1

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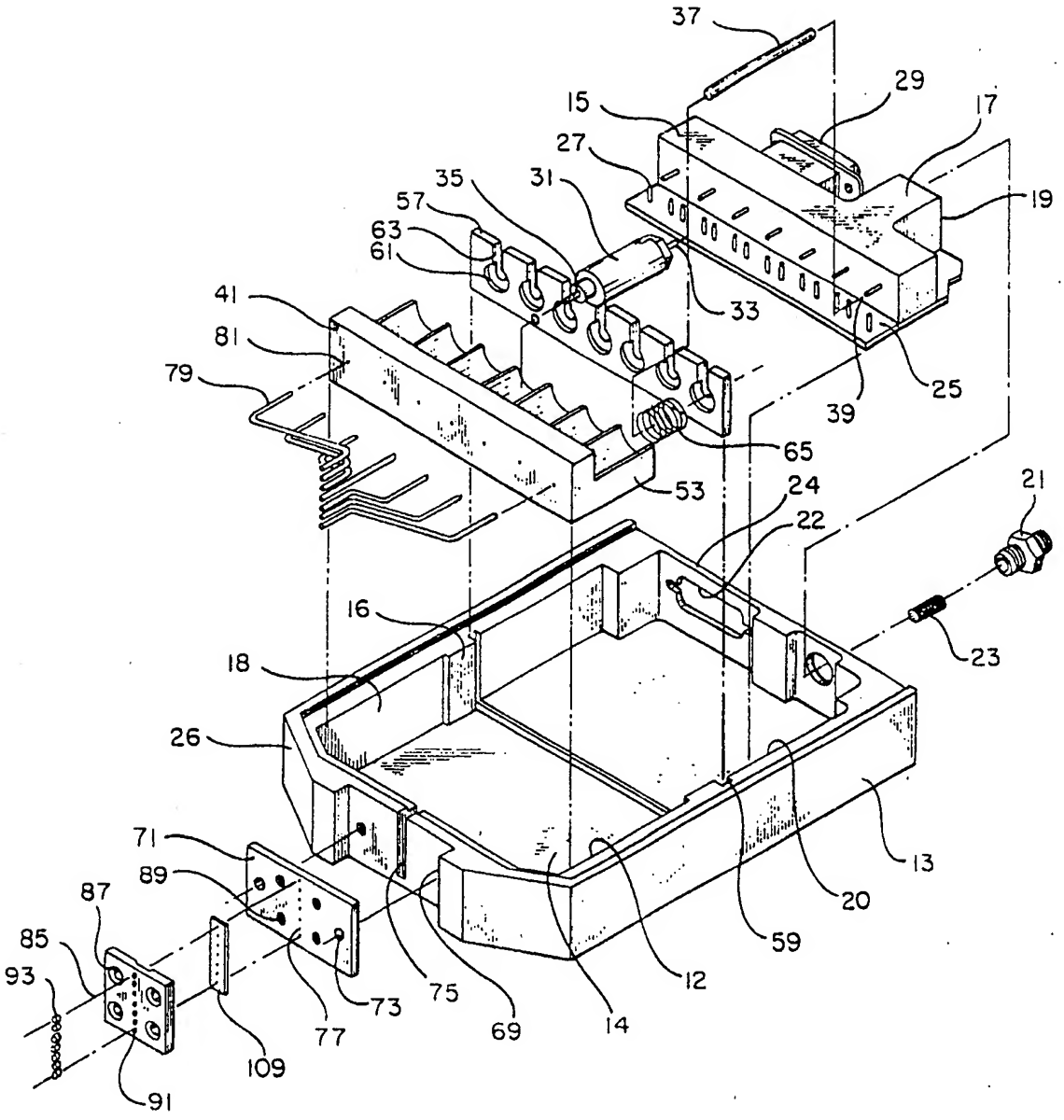
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FIG. 2

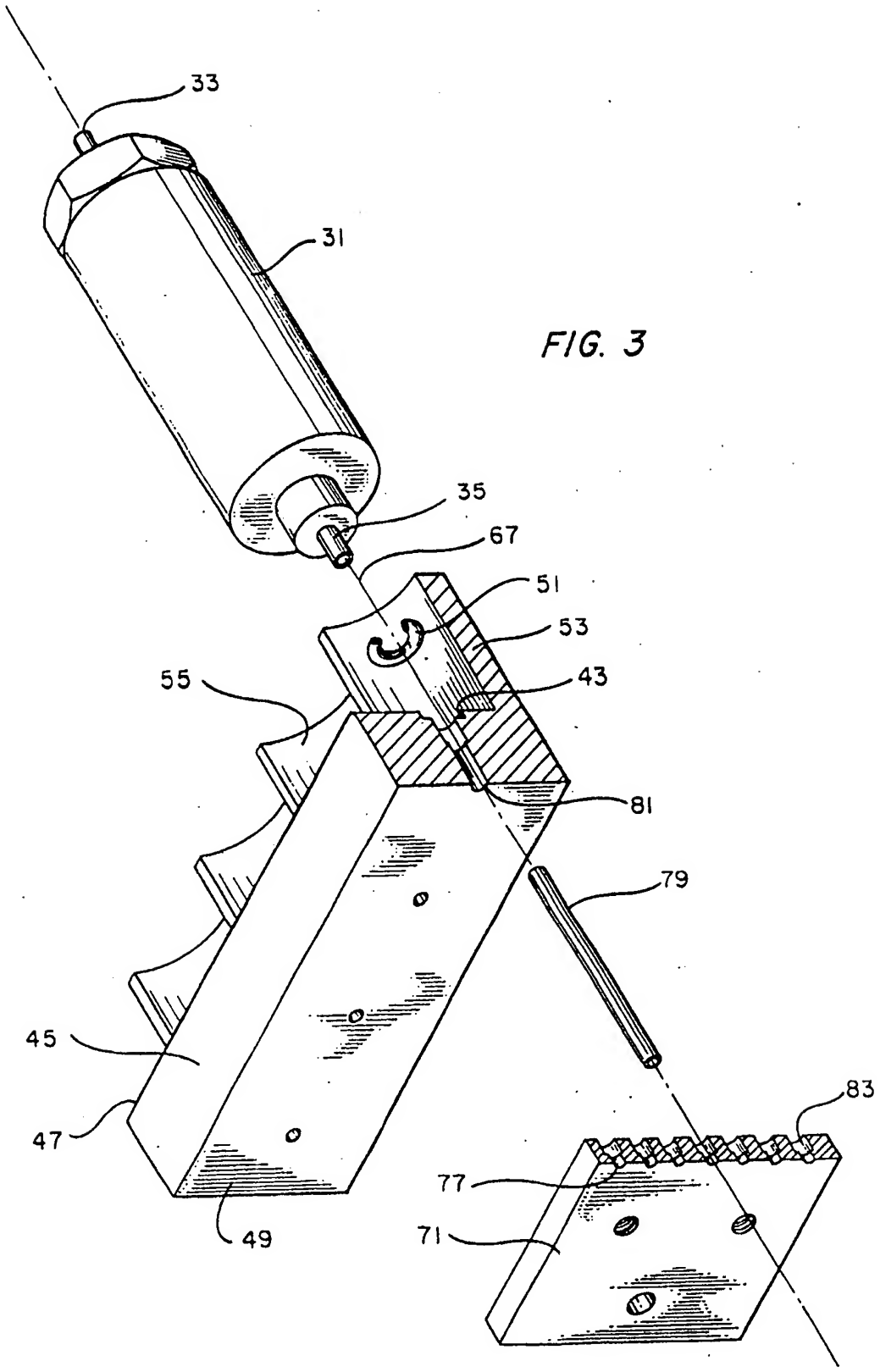

FIG. 3

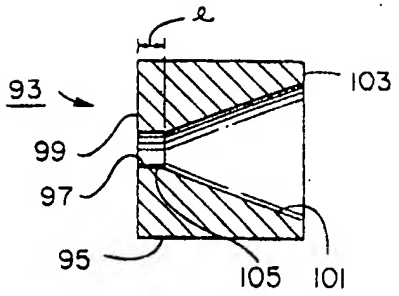

FIG. 5

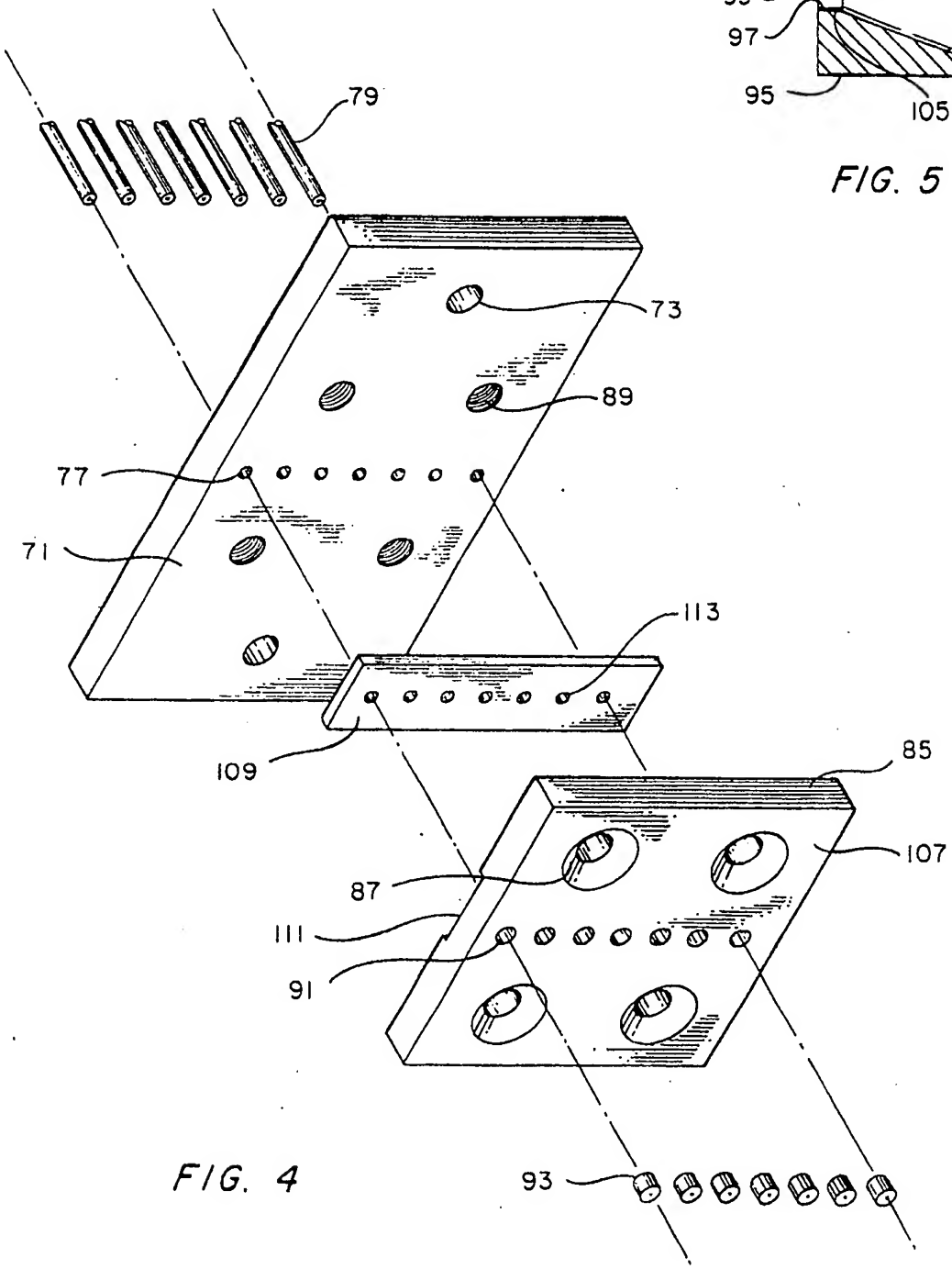

FIG. 4

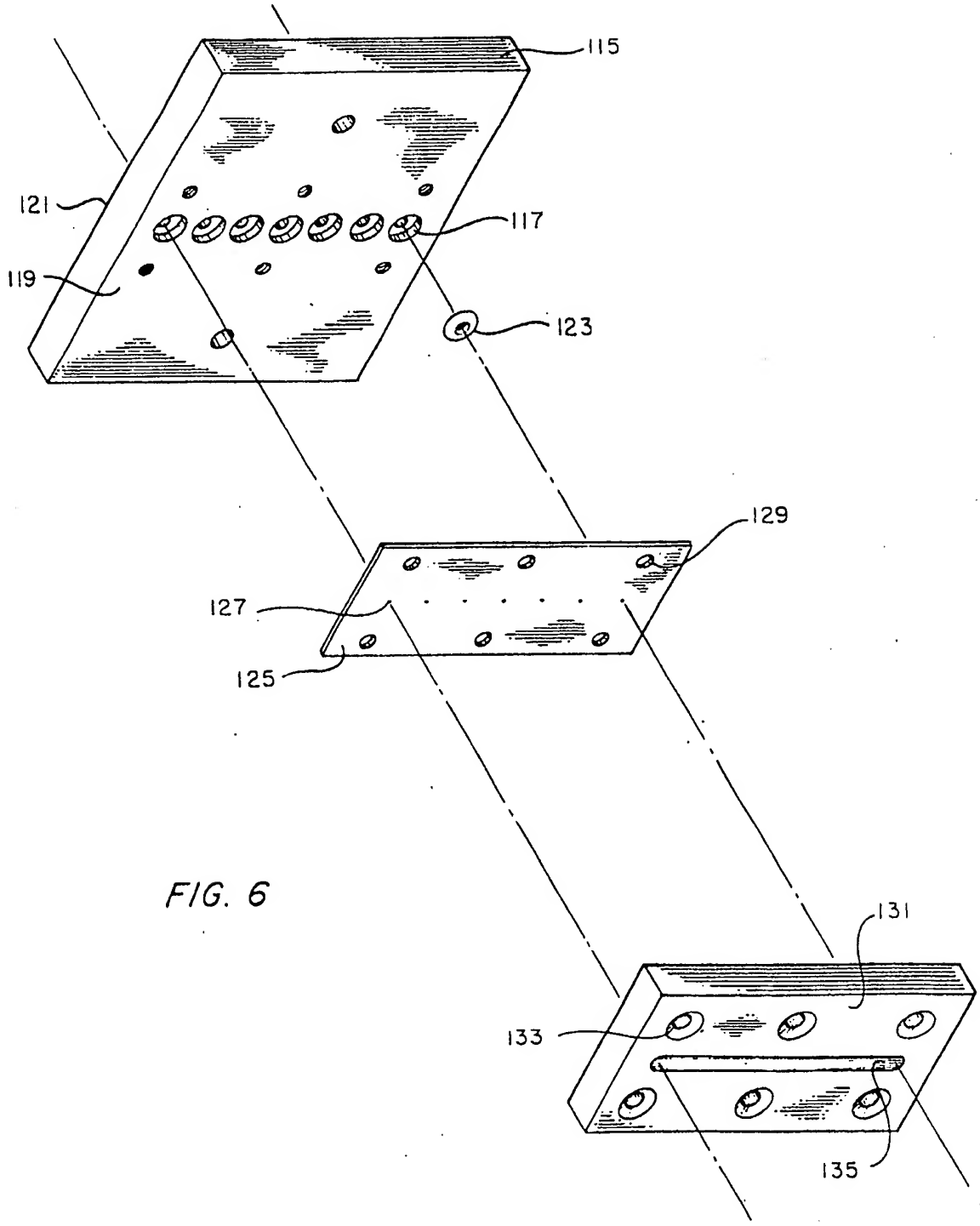

FIG. 6

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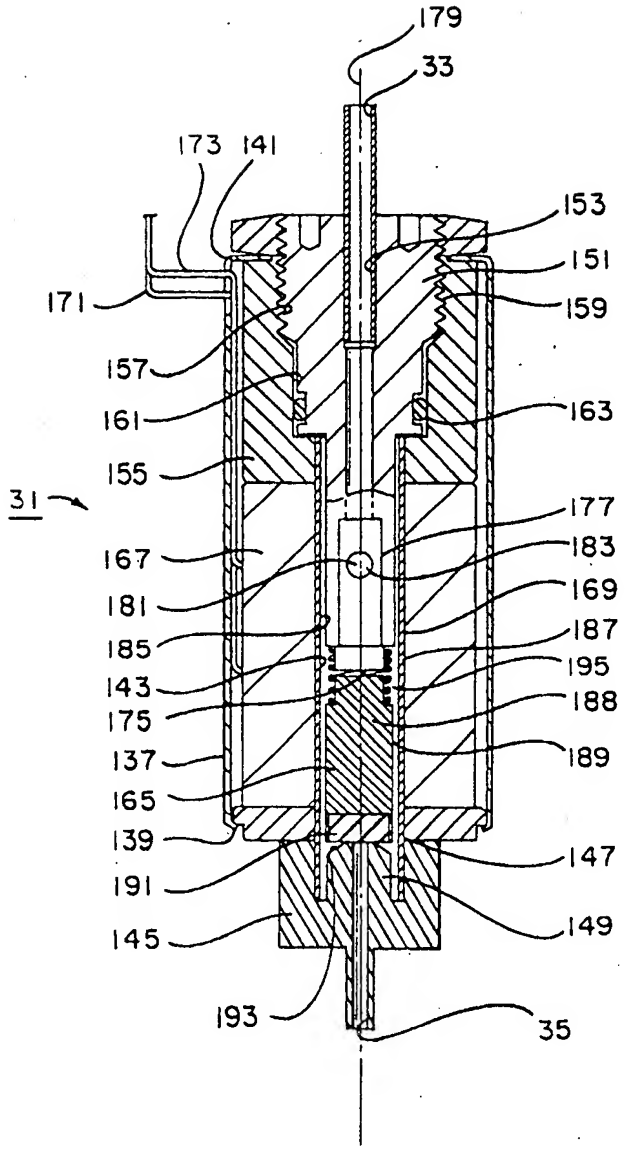

FIG. 7